



INVESTOR IN PEOPLE

The Patent Office  
Concept House  
Cardiff Road  
Newport  
South Wales  
NP10 8QQ

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

In accordance with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L.C. or PLC.

Re-registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules.

Signed

Dated 8 January 2004

Patents Form 1/77  
**THE PATENT OFFICE**  
**B**  
**14 MAR 2003**  
**NEWPORT**

Patents Act 1977  
 (Rule 16)



LARAR03 E792514-1 001097  
 5/1/7750 0.00-0305868.2

# Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

The Patent Office

Cardiff Road  
 Newport  
 South Wales  
 NP10 8QQ

1. Your reference PAT/AT/3102

2. Patent application number

(The Patent Office will fill in this part)

0305868.2

14 MAR 2003

3. Full name, address and postcode of the or of each applicant (underline all surnames)

ROLLS-ROYCE plc  
 65 BUCKINGHAM GATE  
 LONDON  
 SW1E 6AT  
 GREAT BRITAIN

Patents ADP number (if you know it)

3970002

If the applicant is a corporate body, give the country/state of its incorporation

GREAT BRITAIN

10061251+001

4. Title of the invention GAS TURBINE ENGINE COMBUSTOR

5. Name of your agent (if you have one)

"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)

MR V J BIRD  
 INTELLECTUAL PROPERTY DEPT WH 58  
 ROLLS-ROYCE plc  
 PO BOX 3  
 FULTON  
 BRISTOL  
 BS34 7QE

Patents ADP number (if you know it)

65789006

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and (if you know it) the or each application number

Country

Priority application number  
 (if you know it)

Date of filing  
 (day / month / year)

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application

Date of filing  
 (day / month / year)

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? (Answer 'Yes' if:

YES

- a) any applicant named in part 3 is not an inventor, or
  - b) there is an inventor who is not named as an applicant, or
  - c) any named applicant is a corporate body.
- See note (d))

# Patents Form 1/77

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form 0

Description 6

Claim(s) 2

Abstract 1

Drawing(s) 3

10. If you are also filing any of the following, state how many against each item.

Priority documents 0

Translations of priority documents 0

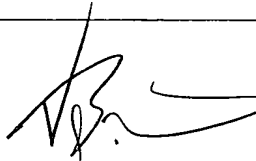
Statement of inventorship and right to grant of a patent (Patents Form 7/77) YES /

Request for preliminary examination and search (Patents Form 9/77) YES /

Request for substantive examination (Patents Form 10/77) NO

Any other documents (please specify) NO

11. I/We request the grant of a patent on the basis of this application.

 Signature  
V J BIRD

Date  
13 MARCH 2003

12. Name and daytime telephone number of person to contact in the United Kingdom ADAM TINDALL 0117 979 4623  
adam.tindall@rolls-royce.com

## Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

## Notes

- If you need help to fill in this form or you have any questions, please contact the Patent Office on 08459 500505.
- Write your answers in capital letters using black ink or you may type them.
- If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.
- If you have answered 'Yes' Patents Form 7/77 will need to be filed.
- Once you have filled in the form you must remember to sign and date it.
- For details of the fee and ways to pay please contact the Patent Office.

Patents Form 7/77

Patents Act 1977  
(Rule 15)

THE PATENT OFFICE  
B

14 MAR 2003



Statement of inventorship and of  
right to grant of a patent

The Patent Office

Cardiff Road  
Newport  
South Wales  
NP10 8QQ

1. Your reference PAT/AT/3102

2. Patent application number  
(if you know it)

0305868.2

14 MAR 2003

3. Full name of the or of each applicant ROLLS-ROYCE plc

4. Title of the invention

GAS TURBINE ENGINE COMBUSTOR

5. State how the applicant(s) derived the right  
from the inventor(s) to be granted a patent

BY VIRTUE OF THE INVENTORS' TERMS AND CONDITIONS OF  
EMPLOYMENT

6. How many, if any, additional Patents Forms  
7/77 are attached to this form? NO  
(see note (c))

7. I/We believe that the person(s) named over the page (and on  
any extra copies of this form) is/are the inventor(s) of the invention  
which the above patent application relates to.

Signature

Date

V J BIRD

13 MARCH 2003

8. Name and daytime telephone number of  
person to contact in the United Kingdom

ADAM TINDALL 0117 979 4623  
adam.tindall@rolls-royce.com

Notes

- a) If you need help to fill in this form or you have any questions, please contact the Patent Office on 08459 500505.
- b) Write your answers in capital letters using black ink or you may type them.
- c) If there are more than three inventors, please write the names and addresses of the other inventors on the back of another Patents Form 7/77 and attach it to this form.
- d) When an application does not declare any priority, or declares priority from an earlier UK application, you must provide enough copies of this form so that the Patent Office can send one to each inventor who is not an applicant.
- e) Once you have filled in the form you must remember to sign and date it.

Enter the full names, addresses and postcodes of the inventors in the boxes and underline the surnames

MICHAEL WESTLAKE  
15 OLD MANOR CLOSE  
CHARFIELD  
GLOS  
GL12 8TS

06511372001

Patents ADP number (if you know it):

SAMUEL MARK SAMPSON  
314 OAKTREE CRESCENT  
BRADLEY STOKE  
BRISTOL  
BS32 9AJ

08588436001

Patents ADP number (if you know it):

Reminder

Have you signed the form?

Patents ADP number (if you know it):

### GAS TURBINE ENGINE COMBUSTOR

The invention relates to a combustor for a gas turbine engine.

In particular it concerns a combustor with an improved air intake chute configuration and a method of manufacture of such a combustor.

The majority of the air entering a combustor enters at the upstream (front) end, usually close to the fuel injection points. The air mixes with and aids the vaporisation of the fuel, which then ignites and burns. Throughout this process the bulk motion of the combusting gas is from the front to the back of the combustor, exiting to the turbine.

This simple air and fuel mixing method does not achieve complete combustion and may result in undesirable unburned carbon and hydrocarbon emissions as well as a non optimal turbine entry temperature profile. A commonly used solution to this situation is to pierce the combustor wall with a plurality of plain holes to provide extra, or 'dilution', air to complete the combustion process. However, because the holes direct relatively small quantities of air into the combustor, usually perpendicular to the bulk flow, the momentum of the dilution air is much lower and therefore will have an insufficient penetration depth to be fully effective. An improvement can be obtained by employing air intake chutes in the holes to shield the dilution air from the main gas flow and help turn the air direction to a steep angle to the main flow.

The air intake chute comprises a tubular section with a flange at one end. The flange has a greater diameter than the hole it is associated with and typically, is attached to the combustor by a number of welds around the flange edge. The location and lengths of the welds are chosen by the operator executing the weld. For practical reasons, such as visibility, especially during a manual welding operation, the weld size will vary in size and location on each air intake chute.

It will be appreciated that stress will be induced in the combustor walls during operation of the gas turbine combustor. The most dominant component of this is the hoop stress. It will also be appreciated that the hoop stress will be concentrated by the air intake holes. Hence it is highly likely that the welds will be positioned in zones of high stress. In such a configuration it is common for cracks to initiate at the weld location which propagate through the combustor wall. This may result in serious damage to the combustor and, consequently, the engine.

According to the present invention there is provided a combustor for a gas turbine engine comprising a combustion chamber wall having formed therein at least one hole for admitting air into the combustion chamber; at least one air intake chute aligned with said hole; during operation a hoop stress field having regions of high and low stress concentration around said hole; wherein said chute is attached to the combustor wall in a region of low stress concentration.

Preferably the chute is attached to the combustor wall in at least two regions of low stress concentration.

Preferably the chute is provided with a flange disposed around one end thereof.

Preferably at least one tab projects from the outer edge of said flange, and the at least one tab is attached to the combustor wall.

According to a second aspect of the invention there is provided a method of manufacturing a combustor as described in any of the preceding four paragraphs comprising the step of aligning the areas where the chute is attached to the combustor with the operational hoop stress field in the combustor wall.

Preferably the areas where the chute is attached to the combustor wall are orientated such that they are in the same radial plane.

Hereinbefore and hereafter a radial plane is taken to mean a plane perpendicular to the longitudinal axis of the engine and/or combustor.

The invention is a combustor and a method of manufacturing the combustor, provided with air intake chutes which are aligned such that the areas where the chute is attached to the combustor wall are positioned away from the regions of concentrated hoop stress which are induced in the combustor walls during operation.

The invention, and how it may be carried into practice will now be described in greater detail with reference by way of example to embodiments illustrated in the accompanying drawings, in which:

Figure 1 shows a section of a gas turbine engine combustor having a plurality of air intake chutes according to the present invention.

Figure 2 (Prior Art) is a diagrammatic view of an air intake chute attachment means.

Figure 3 is a diagrammatic view in the direction of the arrow "A" in Figure 1

Figure 4 is a diagrammatic view of an alternative embodiment in the direction of the arrow "A" in Figure 1

Figure 1 is sectional view of a gas turbine engine combustor 2. The overall construction and operation of the engine is of a conventional kind, well known in the field, and will not be described in this specification beyond what is necessary to gain an understanding of the invention.

The combustor 2 comprises an inner wall 4 and an outer wall 6, joined by a cowl 8 and a metering panel 10. A fuel injector 12 extends through the cowl 8 through a hole 14 where the fuel injector head 16 locates inside a sleeve 18 in the metering panel 10, leaving the end of the injector exposed to the combustion region. The injector head 16



comprises an aperture through which fuel will flow and air passages to allow air entry into the combustion region.

In this example there are two rows of holes 20,22 spaced around the circumference of the walls 4,6. Attached to the walls 4,6 and aligned with holes 22 are chutes 24. These may be cylindrical, the same diameter as hole 22 and have a scarfed end. The chutes 24 are provided with a flange 26 at one end which is of larger diameter than the holes 22. The flange 26, and hence the chute 24, is attached to the combustor wall 4,6 by some suitable attachment means. The flange 26 may, by way of non-limiting example, be welded to the combustor wall 4,6.

In operation, pressurised high velocity air from the engine compressor (not shown) upstream of the combustor 2 is split into three flow paths as it reaches the combustor 2. Some of the air passes through the hole 14 around the fuel injector and through the air passages in the fuel injector head 16 into the combustion region. The majority of the remaining air passes either around the inside of the combustion chamber 2, constrained by the combustor inner (not shown), or passes around the outside of the combustion chamber 2, constrained by the combustor outer casing (not shown) before entering the combustion chamber through holes 20,22.

The combustion process occupies the whole of the combustion chamber 2 but, expressed crudely, can be divided up into a core combustion region (of low air fuel ratio) immediately downstream of the metering panel 10 and a dilution region (of higher air fuel ratio) occupying approximately the latter two thirds of the combustion region before the gas exits the combustor 2 to the turbine (not shown). Holes 20,22 provide air for the dilution. Chutes 24 are required to achieve the required penetration to effectively dilute the combustion region.

It will be appreciated that there is a significant pressure drop between the outside and the inside of the combustor 2 and that the combustor 2 is operating over a wide temperature range. A significant hoop stress is induced in the combustor walls 4,6.

Conventionally the chutes 24 are welded at a plurality of locations 28 around the circumference of the flange 26, as shown in Figure 2 (prior art). The hoop stress field is represented by lines 30 running circumferentially around the combustor wall 46. Hence point "B" and "C" marked on the centre line 30 are in the same radial plane.

It is well known that with this configuration, the hole 22 will concentrate the hoop stress. The regions of peak stress are located at regions indicated by "D" and "E". However, regions of low stress, or "dead zone" are located in regions "B" and "C".

Shown in Figure 3 and in accordance with the present invention, is a similar arrangement to that described in the prior art except that the areas where the chute 24 is attached to the combustor wall 4,6 are located only in the regions of low stress "B","C" which are positioned in the same axial plane and are provided on diametrically opposite sides of the chute 24 and flange 26.

In operation, the present invention will reduce the propensity for weld cracks at the areas of attachment 28. It will be appreciated that cracks initiated at the areas of attachment 28 may propagate to the combustor wall 46, resulting in a critical failure of the combustor 2.

An alternative embodiment of the flange 26 is presented in Figure 4. Tabs 32 are provided such that they project outwardly from the flange 26. The tabs 32 are positioned on diametrically opposite sides of the flange 26 such that when attached to the combustor wall 4,6 they are in the same radial plane.

In this embodiment the flange 26 is attached to the combustor wall 4,6 by welding means. The weld 34 is provided along the outermost edge 36 of the tab 32. The edge 36 may be flat or curved.

It will be appreciated that it is critical to control the length of weld 34 in order to position the attachment point in the regions of low stress "B" and "C". During a manual welding operation the edge 36 enables the weld operator to identify the beginning and end of

the desired weld position. This embodiment offers the surprising advantage that the edge 36 provides a guide for the location and length of the weld during the weld operation.

The size of the tabs 32 are chosen such that the weld 34 is positioned in the low stress regions "B" and "C". It will be appreciated that the tab 32 size will be different for different combustor configurations. However, by way of non limiting example, tab 32 projects up to about  $0.14x$  (flange 26 diameter) and should have a length up to about  $0.25x$  (flange 26 diameter).

It will be appreciated that the tab 32 may be attached to the combustor wall 4,6 by suitable attachment means other than welding.

The configurations shown in Figures 1 to 4 are diagrammatic. The design of the combustor and air intake chute may vary. Likewise the combination, configuration and positioning of these components relative to one another will vary between designs.

**CLAIMS**

- 1     A combustor for a gas turbine engine comprising a combustion chamber wall having formed therein at least one hole for admitting air into the combustion chamber;  
  
at least one air intake chute aligned with said hole;  
  
during operation a hoop stress field having regions of high and low stress concentration around said hole;  
  
wherein said chute is attached to the combustor wall in a region of low stress concentration.
- 2     A combustor as claimed in claim 1 wherein the chute is attached to the combustor wall in at least two regions of low stress concentration.
- 3     A combustor as claimed in claim 2 wherein areas where the chute is attached to the combustor wall are substantially in the same radial plane.
- 4     A combustor as claimed in claim 2 or 3 wherein the areas of attachment are provided on diametrically opposite sides of said chute.
- 5     A combustor as claimed in claims 1 to 4 wherein the combustor air intake chute is provided with a flange disposed around one end thereof.
- 6     A combustor as claimed in claim 5 wherein the flange is circular.
- 7     A combustor as claimed in claim 5 or claim 6 wherein at least one tab projects from the outer edge of said flange.

- 8 A combustor as claimed in claim 7 wherein the at least one tab is attached to the combustor wall.
- 9 A combustor as claimed in claim 7 or claim 8 wherein the at least one tab projects from the edge of the flange up to about  $0.14 \times$  (flange diameter).
- 10 A combustor as claimed in claims 7 to 9 wherein the at least one tab has a length of up to about  $0.25 \times$  (flange diameter) of the diameter of the flange.
- 11 A method of manufacturing a combustor as described in any of the preceding claims comprising the step of aligning the areas where the chute is attached to the combustor with the operational hoop stress field in the combustor wall.
- 12 A method as claimed in claim 11 wherein the areas where the chute is attached to the combustor wall are orientated such that they are in the same radial plane
- 13 Use of a combustor as claimed in claims 1 to 10.
- 14 A combustor substantially as hereinbefore described with reference to Figures 1, 3 and 4.
- 15 A method of manufacturing a combustor substantially as hereinbefore described with reference to Figures 1, 3 and 4.

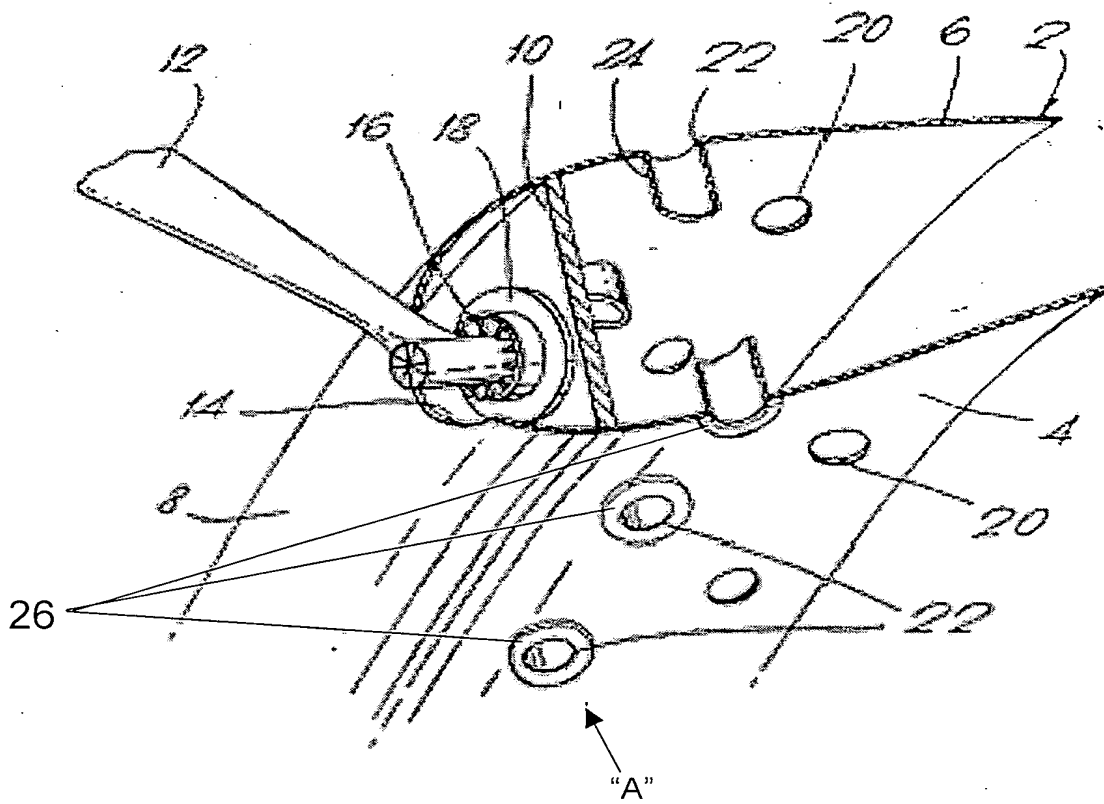


Figure 1

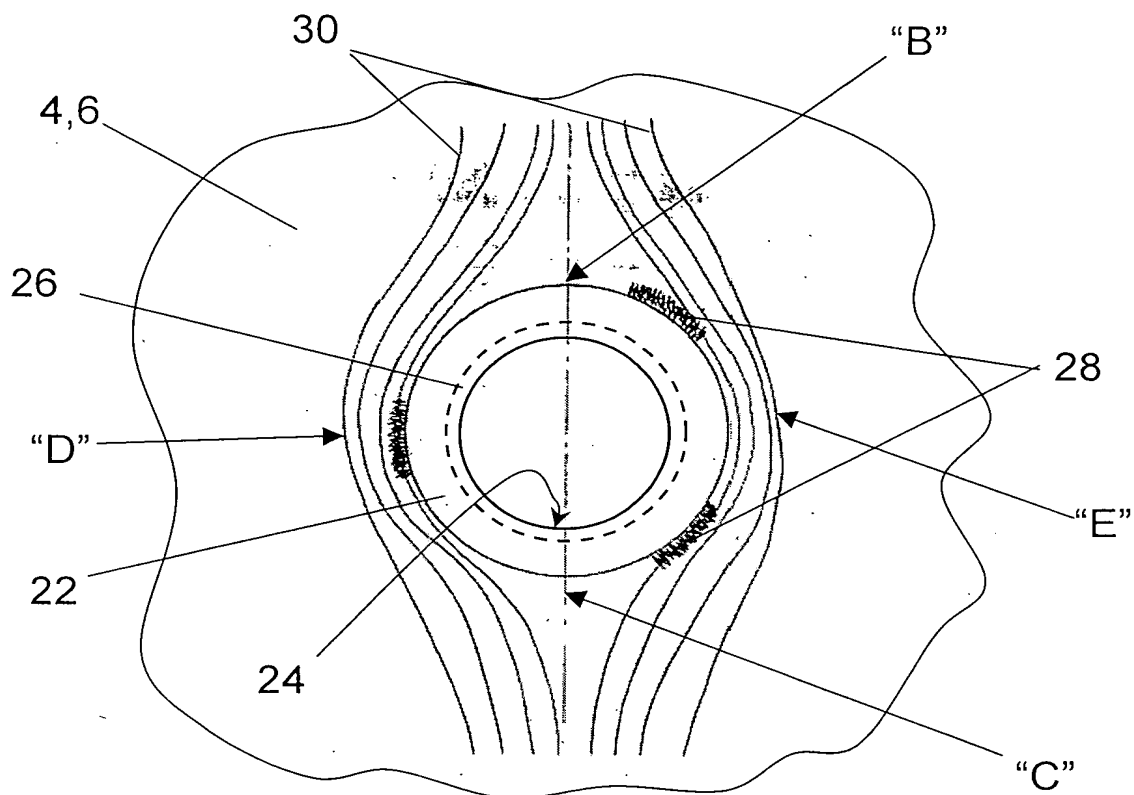


Figure 2 (PRIOR ART)

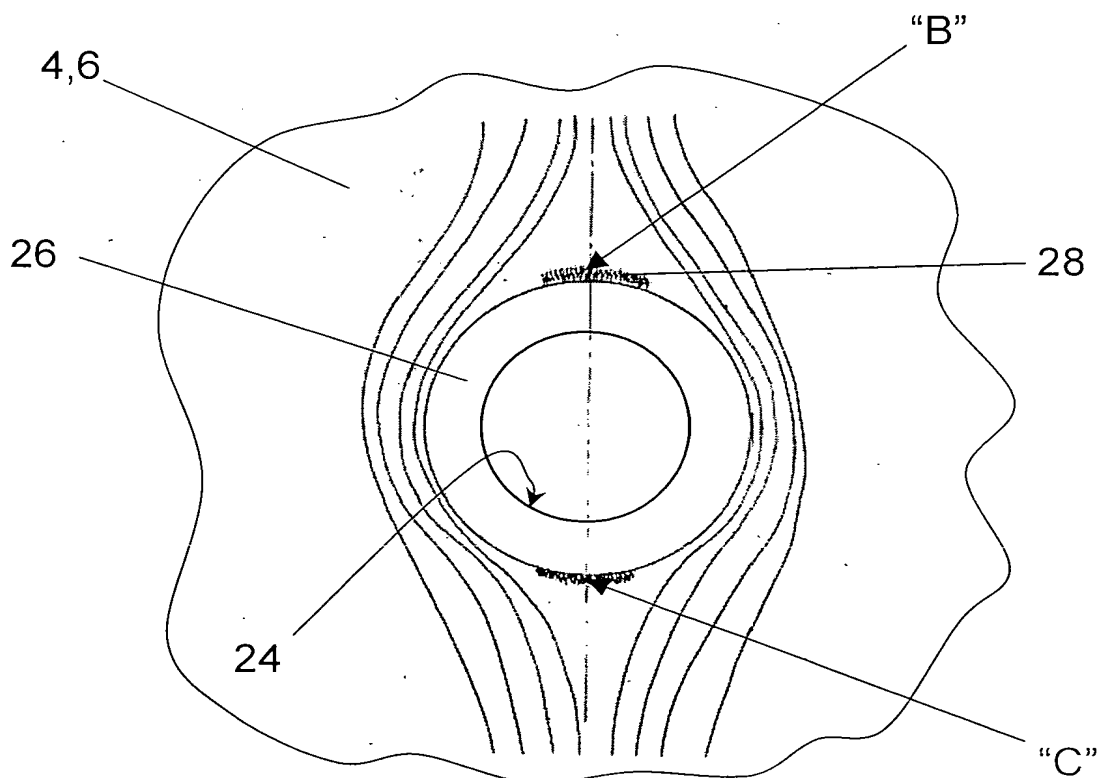


Figure 3

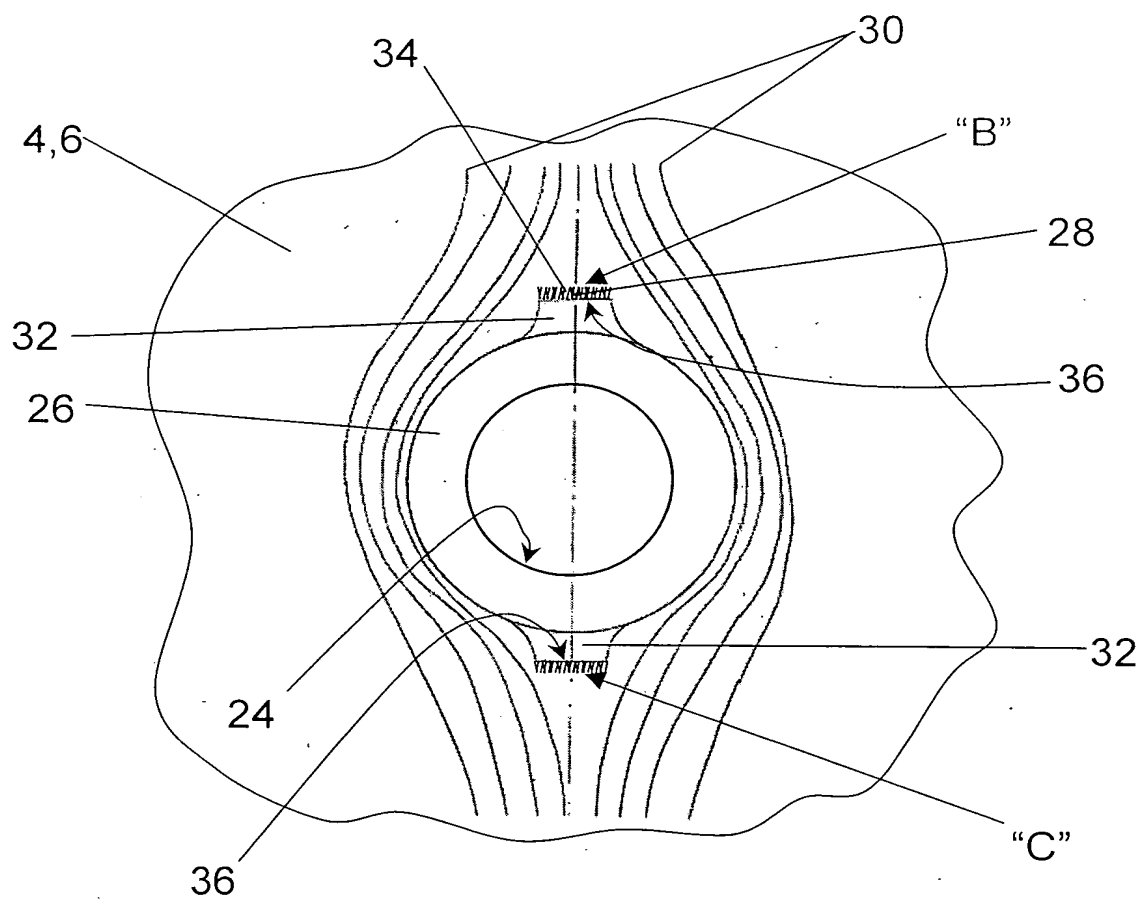


Figure 4